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Boundary layer control system for partic. aircraft - includes several heating elements lying flush with surface for heating boundary layer, and several cooling elements lying flush with surface downstream of heater elements (Eng)

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The control system includes a surface (10) and several heater elements (11) lying substantially flush with the surface for heating the boundary layer. The system also includes several cooling elements (12) lying substantially flush with the surface downstream of the heater elements.

The arrangement is such that boundary layer flow passing over the heater elements is locally heated and thus destabilised. When the flow passes over the cooling elements, the heat flux is directed towards the surface. In this way transition delay of boundary layer is effected. The cooling elements have units for varying the rate of cooling in order to account for variable boundary layer temperature over the surface.

ADVANTAGE - Reduced energy consumption. (4pp Dwg.No.1/2)

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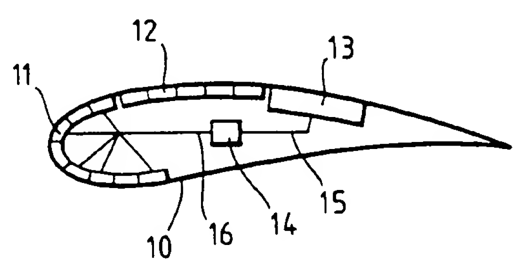

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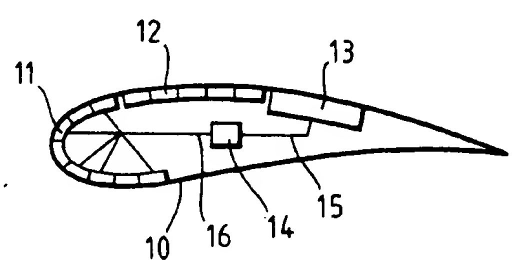
(71) Applicant : BRITISH AEROSPACE PUBLIC LIMITED COMPANY
Warwick House, P.O. Box 87, Farnborough Aerospace Centre
Farnborough, Hants. GU14 6YU (GB)

(72) Inventor : Majdalawi, Fouad
British Aerospace Airbus Ltd., Filton House
Filton, Bristol, BS99 7AR (GB)
Inventor : Nayfeh, Ali Hasan
300 Murphy Street
Blacksburg, Virginia 24060 (US)

(54) Boundary layer control systems.

(57) A boundary layer control system is provided which comprises a surface (10), several heater elements (11) lying substantially flush with the surface (10) for heating the boundary layer and several cooling elements (12) lying substantially flush with the surface (10) downstream of the heater elements (11). The arrangement is such that boundary layer flow passing over the heater elements (11) is locally heated and thus destabilised and when passing over the cooling elements (12) the heat flux is directed towards the surface. In this way transition delay of the boundary layer is effected.

Fig. 1.



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This inv ntion relates to boundary lay r control systems. More particularly it relates to m ans for controlling the laminarity of the flow over a surface.

On known system for controlling the transition of laminar/turbulent flow at a surface is described in US patent 4,786.020 and comprises thin metallic ribbons, disposed adjacent the surface and extending substanitally transverse of the flow of the airstream, which can be vibrated by periodic heating. The patented system thus achieves boundary layer control by controlling the growth or decay of disturbances by amplitude and phase shifting of the disturbances induced by vibration.

US Patent 4,932.610 teaches the active control of boundary layer transition and turbulence which comprises heating elements associated with a surface such as an aerofoil to trigger boundary layer transition and audio speakers to provide acoustic suppression of the boundary layer. The trigger and suppression control are activated by a feedback amplifier which reads boundary layer flow conditions using an anenometer probe. This active control of the boundary layer permits delay of flow separation and a reduction in skin friction drag as compared to natural flow conditions.

According to the present invention there is provided:-

A boundary layer control system comprising in combination:-

a surface,

a plurality of heater elements lying substantially flush with said surface for heating the boundary layer,

a plurality of cooling elements lying substantially flush with said surface for cooling the boundary layer,

the arrangement being such that boundary layer flow passing over said heater elements is locally heated and thus destabilised and when passing over said cooling elements the heat flux is directed towards the surface,

whereby change in location of the transition region is effected.

One embodiment of the invention will now be described, by way of example only, and with reference to the following drawings in which:-

Figure 1 is a typical cross section through an aerofoil section incorporating the present invention.

Figure 2 is a part cross-section to a larger scale through an aerofoil section.

Referring to the drawings, Figure 1 illustrates a typical cross-section through a wing aerofoil 10, the aerofoil incorporating spanwise extending leading edge heater elements 11 and spanwise extending upper surface cooling elements 12 positioned adjacent to, but downstream of, the heating elements 11. In the preferred arrangement a transition detector 13 is mounted downstream of the cooling elements and a feed back amplifier 14 positioned within the wing structure with int rconnecting transmission lin s 15 and 16 joining the transition detector and the leading edge heating lements.

In figure 2, a partial cross section, just a series of cooling elements 17, 18, 19, 20 are shown. At least one of the elements 19 is shown connected to a power supply 21 by which means this particular element 19 can be used as a heat sink to extract heat energy from the flow.

By including cooled elements, the surface cooling may be forced or enhanced. Variable cooling rates may be achieved by the use of variable materials for the cooling elements, thus providing variable thermal conductivity.

In practice, the system may be used either to increase the laminarity of the flow (either the extent of transition from laminar to turbulent flow or the turbulence level in the boundary layer ie: Suppress the disturbance growth in the boundary layer) or trigger transition to turbulent flow.

The system operates such that the transition detector 13 measures some boundary layer flow parameters (e.g. fluctuating velocity measurements). By means of the feed back amplifier 14, the heater elements can be activated (both in position and the degree of heating).

In the case of air flow, the boundary layer flows over elements 11 and is locally heated. However, where the boundary layer flows over the cooling elements 12, which is relatively cooler than element 11, the direction of the heat flux is directed towards the surface.

Overall, this would achieve transition delay similar to the well documented process of overall surface cooling, yet this method may require less energy to achieve the objective of transition (from laminar to turbulent) delay.

Although this embodiment is particularly described in the context of aircraft it is equally relevant to and benefical for marine applicantions. For example the delay of transition or the promotion of laminer flow can be achieved by slightly modifying the said system such that the location of the heater/cooling elements is interchanged.

Claims

1. A boundary layer control system comprising in combination:-

   a surface,

   a plurality of heater elements lying substantially flush with said surface for heating the boundary layer,

   a plurality of cooling elements lying substantially flush with said surface for cooling the boundary layer,

the arrangement being such that boundary layer flow passing over said heater elements is locally heated and thus destabilised and when passing over said cooling elements the heat flux is directed towards the surface,

whereby change in location of the transition region is effected.

2. A boundary layer control system as in claim 1 in which said plurality of cooling elements lie downstream of said heater elements, whereby transition delay is effected.

3. A boundary layer control system according to Claim 1 or 2 in which at least some of said cooling elements include means for varying the rate of cooling in order to account for variable boundary layer temperature over said surface.

4. A boundary layer control system according to Claim 1,2 or 3 in which said plurality of cooling elements are of selectively variable materials and thus variable thermal conductivity.

5. A boundary layer control system according to any of Claims 1 to 4 in which at least some of said plurality of cooling elements include forced cooling means.

6. A boundary layer control system according to Claim 5 in which one or more of said forced cooling elements are connected to a power supply and used as a heat sink to extract heat energy from the flow.

7. A boundary layer control system according to any preceding Claim in which said system further includes a transition detector for measuring boundary layer flow parameters such as fluctuating velocity measurements.

8. A boundary layer control system according to any preceding Claim in which said system further includes a feed back amplifier by which means the activation of said heater elements can be continuously varied if need be both in position and the degree of heating.

9. A boundary layer control system according to any preceding Claim in which said heating elements and said cooling elements are arranged across the surface in both spanwise and chordwise senses and in a pre-defined pattern in accordance with fluid flow requirements.

Fig. 1.

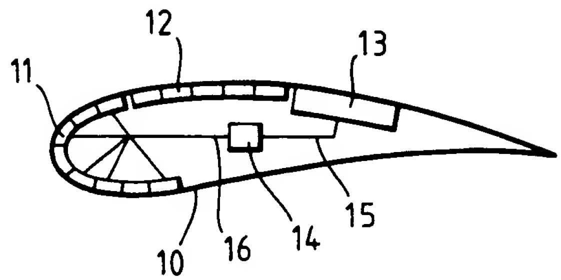
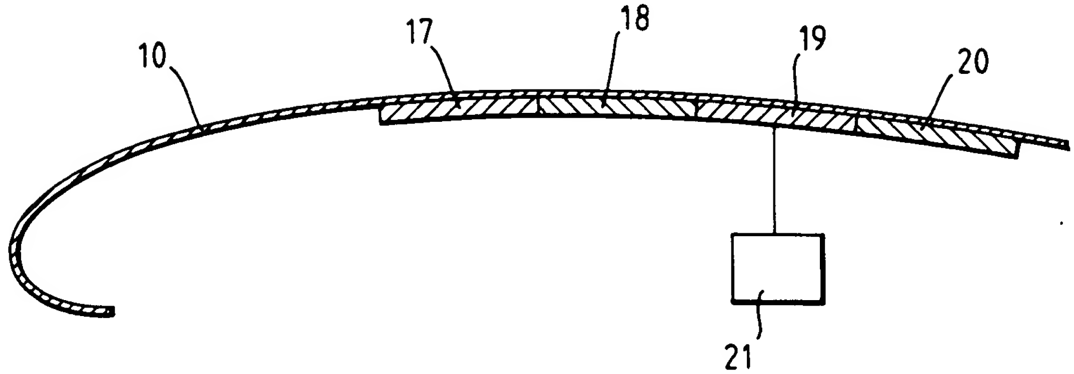


Fig. 2.



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 7622

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	JOURNAL OF FLUID MECHANICS vol. 118 , 1982 , GREAT BRITAIN pages 187 - 200 LIEPMANN ET AL. 'CONTROL OF LAMINAR-INSTABILITY WAVES USING A NEW TECHNIQUE' * page 188, line 4 - line 13 * ---	1	B64C21/00
A,D	US-A-4 932 610 (MAESTRELLO) * column 2, line 17 - line 50 * * column 3, line 17 - line 24 * * column 3, line 38 - line 48 * ---	1	
A	US-A-2 943 828 (VAN DRIEST) * column 1, line 30 - line 57 * * column 1, line 72 - column 2, line 8; claim 1; figures 1,8,13 * -----	1,3	

TECHNICAL FIELDS SEARCHED (Int.Cl.5)

B64C
F15D
B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 December 1993	Zeri, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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